

Cancer Mortality among Printing Plant Workers

MARK H. GREENE,¹ ROBERT N. HOOVER, RAYMOND L. ECK,² AND
JOSEPH F. FRAUMENI, JR.

*Environmental Epidemiology Branch, National Cancer Institute, National Institutes of Health,
U.S. Public Health Service, Department of Health, Education, and Welfare,
Bethesda, Maryland 20205*

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A proportionate cancer mortality study was conducted among employees of the U.S. Government Printing Office. Although limited by small numbers, there was a significantly higher proportion of deaths from multiple myeloma, leukemia, Hodgkin's disease, and colon cancer. The excess deaths from myeloma were confined to white workers in the composing room, where lead is the major occupational exposure, while deaths from leukemia occurred primarily in bindery workers who may have had exposure to benzene. Despite methodologic limitations, these findings are consistent with other epidemiologic and experimental studies suggesting that printers are at higher risk for certain cancers.

INTRODUCTION

In 1926, a proportionate cancer mortality analysis of workers in various trades first suggested that printers might sustain an increased risk of cancer arising from the tongue, liver, and rectum (Young, 1926). Several years later, Steinbruck produced skin cancer and lymphoma in mice by skin painting with printing ink (Steinbruck, 1929). Surveys have since been conducted on various groups of printing workers, with excess risks reported for certain cancer sites, but the results have not been consistent or conclusive (Lloyd, 1977). We were prompted to examine this problem upon seeing two patients with primary hepatocellular carcinoma, both printers employed by the United States Government Printing Office (GPO).

MATERIALS AND METHODS

The U.S. Civil Service Commission's Bureau of Retirement, Insurance, and Occupational Health provided access to a computer file of survivors of federal employees currently receiving death annuity payments. From this listing, we selected individuals whose last government job was the the GPO and identified those GPO employees whose cause of death was coded to cancer. From the claim file on each individual we abstracted the name, date of birth, race, sex, age and year of death, and specific cancer diagnosis recorded on the death certificate. The study period was January 1, 1948, through April 30, 1977. Because of the few deaths among women, the analysis was limited to male employees.

In cooperation with the personnel office, we located the employment record of each individual and abstracted information on job title and duration of employ-

¹ To whom reprint requests should be directed: Environmental Epidemiology Branch, National Cancer Institute, Landow 3C-07, Bethesda, Md. 20205.

² United States Civil Service Commission, Bureau of Retirement, Insurance and Occupational Health, Washington, D.C. 20415.

ment in each job held at the GPO. Information on the age, race, and sex distribution of employees was not available for this study period. All cancer deaths among male employees were stratified by tumor site, race, 5-year age groups, and four time periods (1948–1954, 1955–1959, 1960–1964, and 1965–1977). The observed cancers were compared to age, race, and time-specific expected values derived from a proportionate analysis of all male cancer deaths between 1950 and 1969 in the District of Columbia Standard Metropolitan Statistical Area. Since the vast majority of GPO employees work in a single facility in the center of Washington, D.C., and reside in the metropolitan Washington area, this seemed an appropriate comparison. Age effects were assessed by dividing deaths into three age groups (<60, 60–69, ≥ 70). Finally, cancer deaths were stratified into one of four occupational groups (composers, binders, pressmen, and other) based on the job *longest* held by each decedent. Occupational analysis based on a job *ever* held produced similar results and is not presented in this report.

The statistical significance of the proportionate mortality ratios (PMR) (observed number of deaths/expected number of deaths) was estimated by calculating the 95% confidence interval (CI) around each PMR, assuming that deaths were distributed as a binomial variable. If the lower limit of the CI was greater than 1.0, that PMR was considered significantly elevated.

RESULTS

We identified 347 cancer deaths among male employees: 262 whites and 85 nonwhites (all but one were black). The PMRs are shown for 18 cancer sites by race in Table 1, for selected cancer sites by age group in Table 2, and by occupational category in Table 3. Summarized below are those tumor sites showing a high relative frequency of deaths.

Cancer Sites

The relative proportion of lymphatic and hematopoietic cancers was significantly elevated (PMR = 1.44, CI = 1.1–1.9), with increases seen in whites and nonwhites for multiple myeloma, which accounted for half the excess (PMR = 2.19, CI = 1.2–4.0), Hodgkin's disease, and leukemia (Table 1).

The frequency of hepatobiliary malignancy was also elevated (PMR = 1.47, CI = 0.9–2.5), excluding the two patients with liver cancer who prompted the study. Since the data used to derive the expected values were coded according to the "7th International Classification of Diseases," in which liver and biliary cancers are combined, separate analyses of these two sites could not be done. However, data from the National Center for Health Statistics, 1958–1971, reveal that, in white males, 44% of primary hepatobiliary cancers originated in the liver, and 56% from the biliary tract. The corresponding proportions in nonwhite males were 75 and 28%, respectively (Dr. Thomas Mason, personal communication). Among hepatobiliary cancers in this study, seven of eight (88%) in whites and four of five (80%) in blacks were recorded as primary hepatocellular carcinoma. This suggests that, if appropriate site-specific data were available, there would be a significant excess of primary liver cancer, especially in white employees.

Colon cancer occurred more frequently than expected in both racial groups, but the proportion of rectal cancer deaths was not increased. An excess of prostatic

TABLE 1
PROPORTIONATE MORTALITY RATIOS FOR CANCER SITES AMONG MALE EMPLOYEES OF THE
U.S. GOVERNMENT PRINTING OFFICE, BY RACE, 1948-1977

Tumor site	White			Nonwhite			Total			
	Obs	Exp ^a	PMR ^b	Obs	Exp	PMR	Obs	Exp	PMR	95% CI
All hematopoietic	32	22.64	<u>1.41^c</u>	8	5.22	1.53	40	27.86	<u>1.44</u>	1.1-1.9
Multiple myeloma	8	3.25	<u>2.46^d</u>	2	1.31	1.53	10	4.56	<u>2.19</u>	1.2-4.0
Leukemia	13	9.87	1.32	3	1.70	1.76	16	11.57	1.38	0.9-2.2
Hodgkin's disease	5	2.29	2.18	2	0.75	2.67	7	3.04	<u>2.30</u>	1.1-4.7
Non-Hodgkin's lymphoma	6	7.13	0.84	1	1.46	0.68	7	8.59	0.81	0.4-1.7
Colon	34	24.81	<u>1.37^e</u>	8	6.09	1.31	42	30.90	<u>1.36</u>	1.1-1.8
Liver and biliary tract	8	6.11	1.31	5	2.75	1.82	13	8.86	1.47	0.9-2.5
Prostate	23	21.72	1.06	15	8.83	<u>1.70^f</u>	38	30.55	1.24	0.9-1.7
Bladder	15	10.04	1.49	2	2.07	0.97	17	12.11	1.40	0.9-2.2
Lung	61	73.34	0.83	23	21.70	1.06	84	95.04	0.88	0.7-1.1
Stomach	15	13.34	1.12	8	7.90	1.01	23	21.24	1.08	0.7-1.6
Pancreas	17	14.51	1.17	3	5.28	0.57	20	19.79	1.01	0.7-1.5
Esophagus	10	8.16	1.23	4	7.97	0.50	14	16.13	0.87	0.5-1.4
Rectum	8	9.28	0.86	0	2.25	—	8	11.53	0.69	0.4-1.4
Kidney	7	5.86	1.19	1	1.17	0.85	8	7.03	1.14	0.6-2.2
Mouth and throat	7	10.58	0.66	4	3.35	1.19	11	13.93	0.79	0.4-1.4
Melanoma (skin)	4	2.70	1.48	1	0.11	9.09	5	2.81	1.78	0.8-4.1
Brain	5	6.97	0.72	0	0.83	—	5	7.80	0.64	0.3-1.5
Larynx	3	5.21	0.58	0	2.33	—	3	7.54	0.40	0.1-1.2
Miscellaneous ^g	4	—	—	1	—	—	5	—	—	—
N.O.S.	9	—	—	2	—	—	11	—	—	—
Total	262			85			347			

^a Age/race/time-period-specific proportionate cancer mortality analysis based on data from males in Washington, D.C. SMSA, 1950-1969.

^b Underlined ratios have a 95% CI which does not include 1.0.

^c 95% CI = 1.0-1.9.

^d 95% CI = 1.3-4.8.

^e 95% CI = 1.0-1.9.

^f 95% CI = 1.1-2.6.

^g 1 each—parotid, breast, nasopharynx, maxillary sinus, and face.

cancer was observed only among nonwhite workers. There was also a high proportion of bladder cancer in whites, and cutaneous melanoma in both races. The high relative frequency of certain cancers in the study group was necessarily associated with a lower proportion of deaths from other cancers, particularly of the respiratory tract, rectum, and brain. None of these deficits were statistically significant.

Age at Death

Among workers dying from multiple myeloma, there was a gradient of increasing risk with age (Table 2), with those dying after age 69 showing a significant excess (PMR = 3.42, CI = 1.5-7.7). This trend was observed in both racial groups.

A gradient of decreasing risk with increasing age was seen for both colon and prostate cancers, with the trend more pronounced in whites than nonwhites. Proportionate mortality from prostatic cancer was significantly high among workers dying before age 60 (PMR = 3.06, CI = 1.4-6.4).

TABLE 2
PROPORTIONATE MORTALITY RATIOS FOR SELECTED CANCER SITES AMONG MALE EMPLOYEES
OF THE U.S. GOVERNMENT PRINTING OFFICE, BY AGE GROUP, ALL RACES

Site	<60			60-69			≥70		
	Obs	PMR ^a	95% CI	Obs	PMR ^a	95% CI	Obs	PMR ^a	95% CI
Multiple myeloma	2	1.32	0.4-4.6	3	1.90	0.6-5.4	5	<u>3.42</u>	1.5-7.7
Colon	12	1.57	0.9-2.6	15	1.42	0.9-2.2	15	1.18	0.7-1.8
Prostate	6	<u>3.06</u>	1.4-6.4	10	1.19	0.7-2.1	22	1.09	0.7-1.6

^a Underlined ratios have a 95% CI which does not include 1.0.

Occupation

The excess of multiple myeloma was restricted to white composing-room employees (PMR = 5.33, CI = 2.7-10.1), who had eight of the ten deaths from this cause (Table 3). Leukemia deaths were mainly in white bindery workers (PMR = 3.15, CI = 1.2-7.2), while deaths from colon cancer were uniformly distributed among the various occupational groups.

DISCUSSION

Among the many reports dealing with the occurrence of cancer in printing workers, four have reported no excess of malignancy (Registrar General, 1958;

TABLE 3
PROPORTIONATE MORTALITY RATIOS FOR SELECTED CANCER SITES BY EMPLOYMENT CATEGORY
AMONG MALE EMPLOYEES OF THE U.S. GOVERNMENT PRINTING OFFICE, BY RACE

Site	Occupation	White		Nonwhite		Total		
		Obs	PMR ^a	Obs	PMR ^a	Obs	PMR ^a	95% CI
Multiple myeloma	Total GPO	8	<u>2.39</u>	2	1.53	10	<u>2.15</u>	1.2-4.0
	Compositors	8	<u>5.33^b</u>	0	—	8	<u>5.13</u>	2.6-9.7
	Binders	0	—	0	—	0	—	—
	Pressmen	0	—	0	—	0	—	—
	Other	0	—	2	2.63	2	1.39	0.4-5.0
Leukemia	Total GPO	13	1.32	3	1.76	16	1.38	0.9-2.2
	Compositors	4	0.87	0	—	4	0.86	0.3-2.1
	Binders	4	<u>3.15^c</u>	1	1.89	5	<u>2.78</u>	1.2-6.0
	Pressmen	3	1.56	1	3.33	4	1.79	0.7-4.3
	Other	2	0.89	1	1.22	3	0.97	0.3-2.7
Colon	Total GPO	34	<u>1.37</u>	8	1.31	42	<u>1.36</u>	1.1-1.8
	Compositors	15	1.32	0	—	15	1.31	0.8-2.1
	Binders	3	0.86	4	1.85	7	1.24	0.6-2.4
	Pressmen	9	1.84	1	0.70	10	1.58	0.9-2.7
	Other	7	1.37	3	1.00	10	1.23	0.7-2.1

^a Underlined ratios have a 95% CI which does not include 1.0.

^b 95% CI = 2.7-10.1.

^c 95% CI = 1.2-7.2.

Dunn, 1968; Pasternack, 1972; Cole, 1972). In the remaining publications, excess risks have been reported, most often for cancers of the lung (Henry, 1931; Registrar General, 1938; Kennaway, 1947; Guralnick, 1963; PHS, 1967; Greenberg, 1972; Moss, 1972; Hoover, 1975), large bowel (particularly rectum) (Young, 1926; Guralnick, 1963; PHS, 1967; Milham, 1976; Lloyd, 1977; NIOSH, 1977a), oral cavity (especially tongue) (Young, 1926; Greenberg, 1972; Milham, 1976; Lloyd, 1977; NIOSH, 1977a), bladder (Young, 1926; Henry, 1931; Badger, 1962) and leukemia or lymphoma (Guralnick, 1963; Hueper, 1964; PHS, 1967; Viadana, 1972; Greenberg, 1972; Registrar General, 1972; Milham, 1976). Less consistently noted among printers have been elevated rates for cancers of the liver (Young, 1926; Hoover, 1975), pancreas (Lloyd, 1977; NIOSH, 1977a), prostate (Henry, 1931), and larynx (Kennaway, 1947). These studies are difficult to compare because of differing methodologies and diverse study groups connected with the printing industry, including pressmen (newspaper or commercial), compositors, plate makers, and unspecified job categories. Our survey included both printing production workers and support personnel who were not directly involved in the printing process.

Printing workers have been exposed to a panoply of potentially toxic substances, including pigments, inks, solvents, resins, driers, plasticizers, and wetting agents. It has been suggested that some printing pigments (e.g., lead chromate, lead molybdate, carbon black, and cadmium disulfide) may be carcinogenic in laboratory animals (Kay, 1976). Polychlorinated biphenyls (PCBs) (NIOSH, 1976) and 2-nitropropane, both printing ink constituents, have caused hepatocellular carcinoma in rodents (NIOSH, 1977b), and three benzidine-derived dyes (direct black 38, direct blue 6, and direct brown 95) are also hepatic carcinogens (NIOSH/NCI, 1978). Lead compounds can produce renal tumors (McCreary, 1977) and lymphomas (Epstein, 1968) in experimental animals, and can suppress immune function as well (Luster, 1978). None of these particular substances are known to have been used at the GPO. The solvents used contain varying mixtures of toluene, xylol, ethyl acetate, and 1,1,1-trichloroethane, none of which are known or suspected carcinogens. Benzene has been used at the GPO only on a limited basis for some specialized processes, particularly in the bindery. In general, the quality of industrial hygiene at the GPO is excellent; and a concerted effort has been made over the years to minimize toxic exposures.

The present study, despite its limitations, suggests that printing workers are at increased risk of hematopoietic neoplasms, particularly multiple myeloma, but also leukemia and Hodgkin's disease. Compositors were especially prone to myeloma, and bindery workers to leukemia. The main exposure sustained by composing-room workers is to inorganic lead, both particulate and vapor, although periodic environmental studies at GPO have shown lead exposure to be less than that recommended by OSHA since the early 1940s. A correlational study reported a positive association between drinking water lead levels and multiple myeloma mortality (Berg, 1972), and a study of death certificates in Washington State suggested a possible relation between lead smelting and multiple myeloma (Milham, 1976), both findings in need of further investigation. Bindery workers have been exposed to a variety of adhesives which, until recently, were organic animal-based products that are considered nontoxic. However, benzene is known

to produce leukemia following occupational exposure (Infante, 1977), and was used in the bindery until the early 1960s because of difficulties finding a satisfactory substitute.

Colon cancer also occurred excessively in this series of printing workers, but its effect over all occupational subgroups and races suggests a relation to socioeconomic and lifestyle variables rather than job-specific exposures. In previous reports of colorectal cancer among printers, the increase has ranged from 30 to 100%, with compositors, typesetters, and pressmen at greatest risk (Young, 1926; Guralnick, 1963; PHS, 1967; Milham, 1976; Lloyd, 1977; NIOSH, 1977a). In addition, our survey revealed a relative excess of hepatobiliary cancer. This finding seems consistent with the elevated mortality rates for hepatobiliary cancers in U.S. counties involved in the manufacture of printing inks (Hoover, 1975), and experimental studies showing hepatocarcinogenicity of printing ink constituents (NIOSH, 1976, 1977b; NIOSH/NCI, 1978).

Nonwhite workers had a significantly elevated proportion of prostatic cancer, particularly at younger ages and across all occupational groups. The predisposition of blacks in the general population to prostate cancer does not explain these results, since race- and time-specific mortality data were used to compute the expected values. Cadmium, used in some specialized processes in GPO, is a suspected risk factor for prostatic cancer (Kipling, 1967). However, to our knowledge, none of the prostatic cancer cases had jobs associated with cadmium use.

The age trends noted for some cancers (myeloma, colon, and prostate) may reflect changing work exposures, since during this study period the GPO printing operation shifted from letterpress to offset techniques. Other factors may also be involved, such as the latent period for various occupational cancers.

Several methodologic issues merit comment. First, ascertainment of cancer deaths among GPO employees was incomplete. Not included in our series were employees who (a) transferred to another federal agency prior to retirement, (b) were not employed for at least 5 years to establish retirement eligibility, or for 18 months for survivor benefits in the case of a death in service, (c) had no survivor or whose survivor failed to claim his death annuity, (d) no longer have a living survivor collecting benefits, and (e) withdrew pension benefits as a lump sum upon retirement. Considering that we have adjusted for age in the analysis, none of these reasons for missing cases are cancer site specific and, thus, should not have biased the distribution of cancer types identified. A proportionate analysis was mandated by the unavailability of suitable denominators to permit a cohort analysis.

The study covered the time period 1948–1977, while the available mortality data were for 1950–1969. The mortality rates for 1965–1969 were used to calculate expected values for workers who died between 1965 and 1977; this might distort the risks for cancers with changing mortality rates (e.g., an overestimate of risk for lung cancer, multiple myeloma, and melanoma and an underestimate for stomach cancer). This effect does not explain the excesses observed, since the PMRs showed little variation over the four time periods.

Finally, when multiple comparisons are made in the absence of clear, prior hypotheses, some “significant” associations will be observed on the basis of

chance alone. The confidence intervals provide guidance in interpreting the data, but do not indicate that definitive conclusions have been reached. Thus, our findings are consistent with other epidemiologic and experimental studies suggesting that printers are at higher risk for certain cancers, but need clarification by carefully designed cohort studies of selected occupations in the printing trades, in which the specific exposures can be characterized.

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